Electrical Severity Ranking Tool

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Occurrence Reporting Task Group

Electrical Incident/Accident Critiques and Reports

- What is “hazardous” electrical energy?
  - some is harmless
  - some hurts
  - some cripples
  - some can kill
- Describing electrical energy
  - voltage, current, power, energy, waveform
- Sources
  - power, equipment, dc, capacitors, batteries, rf
- What is “unexpected discovery”?
  - I never expected to find it?
  - I suspected it could be there?
  - I didn’t know for sure where it might be?
  - engineering controls failed?
- How to I take into account that I used methods to protect me, in case I encountered electricity?

Problems with Reporting

- Lack of understanding of
  - the level of hazard
  - the potential for injury
  - the standards for protection
- has led to some events being
  - over reported,
  - under reported, or
  - not reported at all
- Our process for critiques and reports may not lead us to the right lessons learned and corrective actions

Goals

- We need better tools for assessing and reporting electrical accidents and incidents
- We need a consistent process for evaluating electrical incidents across the DOE complex
- We need tools to help gather the relevant electrical information during a critique

EFCOG/DOE Electrical Safety Improvement Project Task Group 4

- Develop tool(s) to be used to evaluate electrical incident severity
- Utilize quantitative methods based on national codes and standards
- Deploy complex-wide assuring consistent application

Components of Method

- The proposed solution is a two part package:
  - Electrical Severity Ranking Tool
  - Electrical Severity Index Tool

Electrical Severity Ranking Tool

- Used by an electrical Subject Matter Expert (SME) will require the gathering of the necessary electrical data
- Quantifies the electrical hazard based on national codes and standards
- Quantifies exposure to the hazard based on national codes and standards
- Quantifies injury based on short term and long term effects

Electrical Severity Index Tool

- Normalizes incidents at a site to the number of work hours performed

Purpose of the Proposed Tools

- The proposed tools are NOT intended to:
  - assess the worker's qualification
  - assess work control in place
  - assess human behavior

- The proposed tools DO
  - force the gathering of the necessary technical information
  - provide a quantitative severity ranking based on codes
  - account for some protective measures
  - provide a method of trending based on site size

Electrical Event Severity Ranking Methods

- **Electrical Severity = (Electrical Hazard Factor) * (1 + Environment + Shock Proximity + Arc Flash Proximity + Thermal Proximity) * (Injury Factor)**

- **ESI= $\frac{200{,}000[(ES_1) + (ES_2) + (ES_n)\ldots.]}{\text{(hours worked)}}$**

A Little Recent History

- The development of these proposed tools is very recent.
- Driven by a need to better understand, critique, and report on incident investigation and reporting.
- Driven by the disparate nature of reporting within a single site, and from site to site.

DOE called for a New Perspective

- DOE/NNSA Los Alamos Site Office requested that the electrical Authority Having Jurisdiction analyze 34 electrical incidents and provide recommendations
- The Electrical Safety Committee subcommittee
  - self organized
  - set the agenda
  - reviewed previous concepts (SRNL, EFCOG)
  - determined the methods, and
  - produced the product

Occurrence Report

- 3 Officers of the ESC, CESO, HSR DDL, Electrical Inspector Team Lead, Occurrence Analyst, GESO

- 160 Page report
  1 Introduction
  2 LANL Electrical Safety Program
  3 Analysis of Electrical Events
  4 Institutional Recommendations
  5 Recommended Reporting Tools
  Appendices- ORPS Events, Weighting Data, ESO survey

- Presented – Director, ESC, IAB, LASO, national meetings, EFCOG

Analysis of Each Event included

- Category
- Severity Ranking
- Primary Cause
- Human Factors
- Requirements Compliance
- Comments on ORPS Corrective Actions
- Subcommittee Recommendations
- Comments on ORPS Lessons Learned
- Additional Subcommittee Lessons Learned
- Comments on ORPS Report

Problems with Current System

- ORPS Process seems to result in:
  - Inconsistent reporting
  - Incomplete details when dealing with Electrical
  - Improper categorization
  - Lack of SME agreement on level of hazard
  - In addition, use of the ORPS reporting matrix varies significantly depending on the occurrence investigator, the SME(s), the DOE/NNSA facility representatives, or the managers present at the critique

Examples of ORPS Issues

- Data for Event was not standardized enough to capture relevant event conditions
- Examples
  - Shredder, failure to apply LOTO to mechanical hazard- Not an Electrical Event
  - Mower, was an electrical event, ORPS missed the point
- 4 events for the period analyzed were more significant than ORPS captured
- 11 in agreement
- 18 were less significant

SRS Reporting Tool

- Factors in a rolling average and over simplifies electrical factors

Proposed metric: Electrical Severity Index (ESI):

$$ESI = \frac{200{,}000[(Event1x\ wf) + (Event2\ x\ wf) + (Eventn\ x\ wf)\ldots.]}{(hours\ worked)}$$

where:

ESI= electrical severity index

200,000= constant (man hours for an 100 person work force)

Event= electrical safety event

Hours worked= actual work hours for work population

–Note: same as hours used to calculate OSHA Recordable Case Rate (RCR)

SRS Reporting Tool

- Weighting Factor:

wf= weighting factor based on severity of event as defined below:

a. electrical hazard condition—1
b. LO/TO condition—2
c. near miss: contact with electrical source defined in table 1

Table 1. Near Miss – Weighting Factors

Source description	>50 and =250 volts and>5mA	250-600 volts and >5 mA; OR Stored energy >10 J and = 50 J	>600 volts and =5 mA; OR Stored energy > 50 J
Weighting factor	3	4	5

d. Electrical shock: per table 2

Table 2. Near Miss – Weighting Factors

Source description	<50 and =250 volts; and >5mA	250-600 volts and =5 mA; OR Stored energy >10 J and = 50 J	>600 volts and =5 mA; OR Stored energy > 50 J
*Weighting factor	6	7	8

e. Injury/Burn:
   -minor injury: 10
   -temporary disability: 20
   -permanent injury/disability: 50
f. Fatality: 100

*Need wf for research applications

A New Severity Ranking Tool

Severity Significance =
(Electrical Hazard Factor) *
(1 + Environment + Shock Proximity + Arc Flash Proximity + Thermal Proximity) * (Injury Factor)

This tool was used on nearly 50 electrical incident examples, and works very well, in the opinion of the subcommittee SMEs.

A New Severity Ranking Tool

Severity Significance =
(Potential for Injury) *
(How close did you come, were you protected?) *
(Were you injured?)

The first two factors are based on national codes and standards:
(1) electrical hazard classification
(2) allowed approach boundaries and proper PPE

The tool MUST be used by an SME who understands:
- electricity
- national codes and standards for electrical work

The Potential for Injury

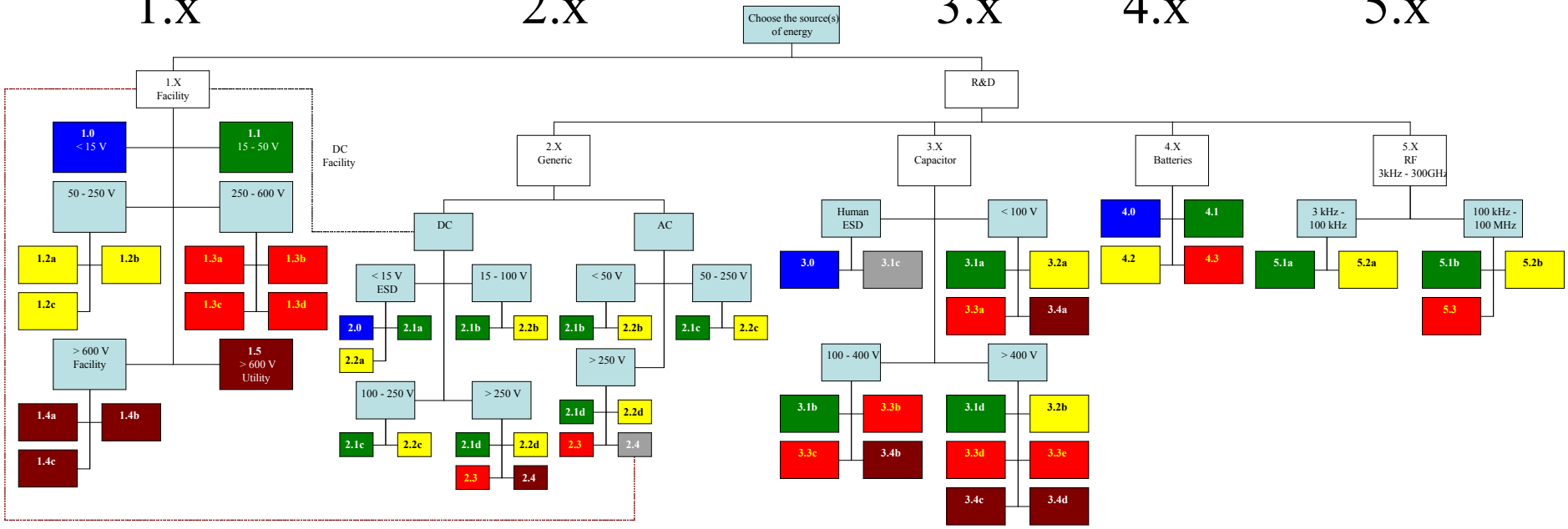
- **Electrical Hazard Factor**

blue-no hazard	0
green-low hazard	1
yellow-moderate hazard	3
orange-high hazard	50
red-very high hazard	100

The Electrical Hazard Factor is determined by the Electrical Hazard Classification Tables.

Electrical Hazard Classification Organizational Table

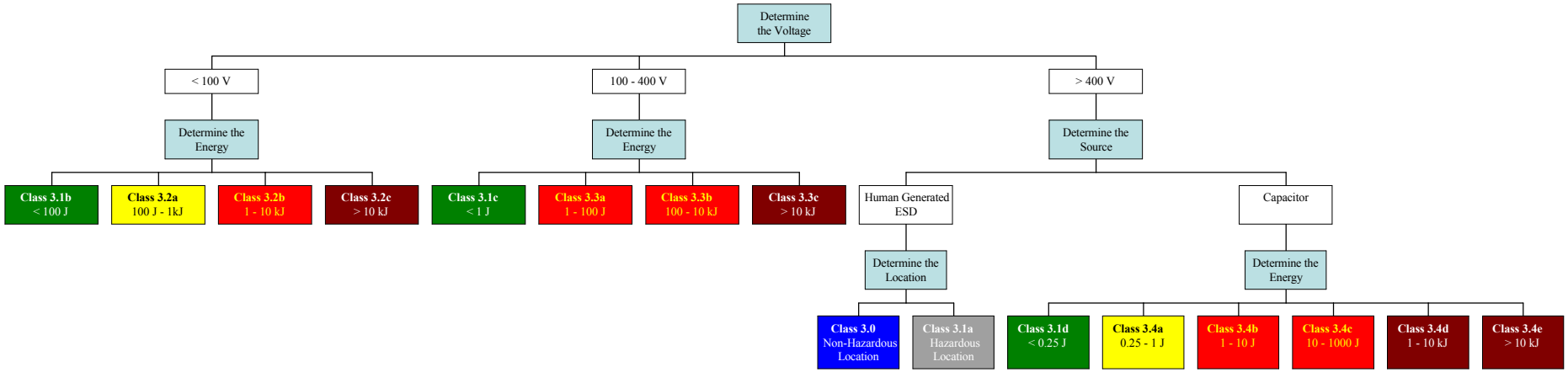
1.x 2.x 3.x 4.x 5.x



AC DC capacitor batteries RF

hazards - covers ALL electrical hazards

Classification Table 3.X: Capacitors



hazards - electrocution, high current, blast, magnetic force

Event Conditions

Environment

Dry	0
Damp	5
Wet	10

The Environment Factor is determined by the condition most commonly found in the area of the event. (Dry is indoors unless otherwise noted, Damp is outdoors, Wet is assumed when water could be or was involved.)

Event Conditions

Shock Proximity

Outside Limited Approach Boundary	0
Within Limited Approach Boundary	1
Within Restricted Approach Boundary	3
Within Prohibited Approach Boundary	10

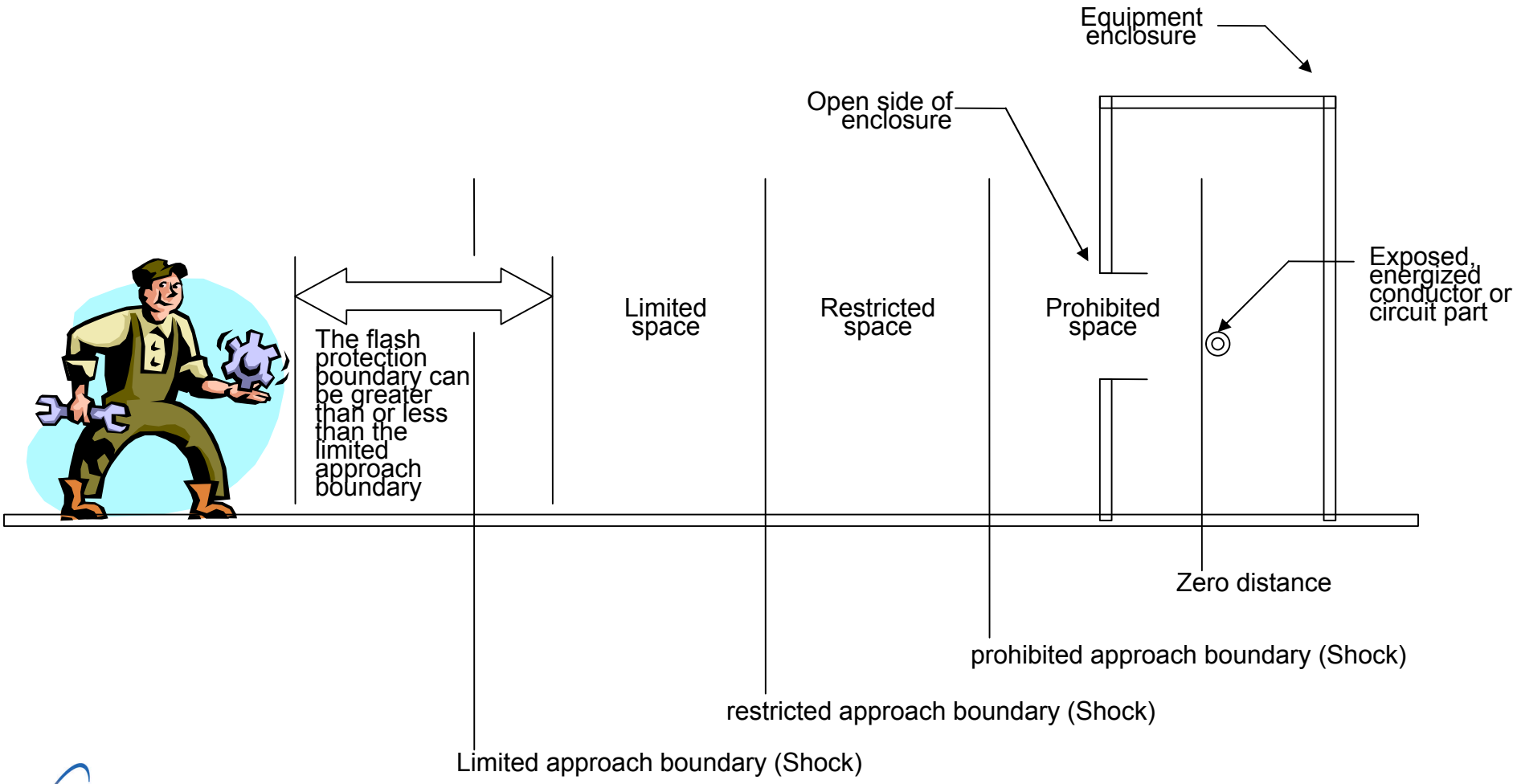
As determined by the approach boundary in Table 130.2(C) of NFPA 70E.

Arc Flash Proximity

Outside Arc Flash Boundary	0
Inside Arc Flash Boundary	10

The Arc Flash Proximity Factor is determined by a Flash Hazard Analysis found in NFPA 70E 130.3(A) (>250V).

Boundaries for Electric Hazards



Event Conditions

- **Thermal Proximity**

	Power	
	1-30kW	*>30kW*
No contact	0	0
Contact	3	10

The Thermal Proximity Factor is determined by the amount of human contact with the conductive media and the power available to the contacting media (below 50V).

- **PPE**

correct for Environmental	reduces the environmental factor to	0
correct for Shock Proximity	reduces the Shock Proximity factor to	0
correct for Arc Flash Proximity	reduces the Arc Flash Proximity to	0

Reduces the factor with the use of the correct PPE for the electrical hazard.

Injury Sustained

- **Injury Factor**

none	1
shock (no fibril), burn (1st degree)	3
arc flash/blast (2nd degree)	5
effects on heart	10
permanent disability	20
fatality	100

The injury factor is determined by the worker(s) injury.

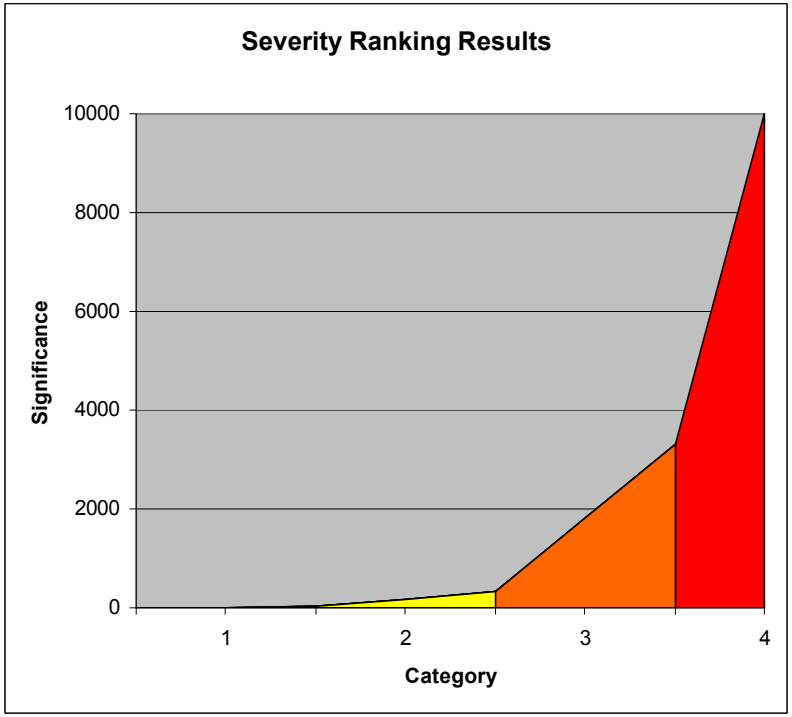
Severity Score

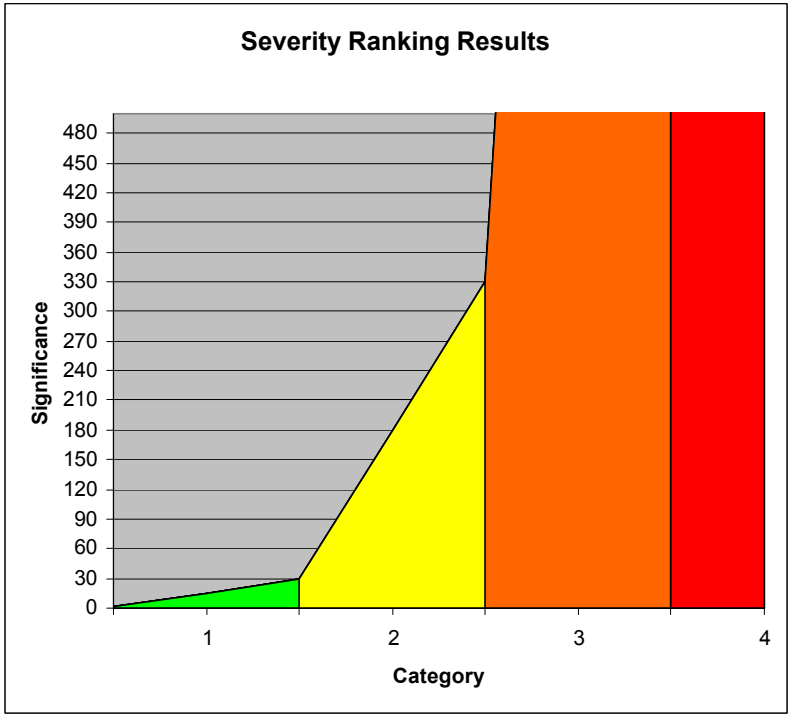
- **Severity Significance**

	Severity index score	log	possible ORPS
Extreme	= 3300	> 3.5	1/2
High	330 - 3300	2.5 - 3.5	3
Medium	30 - 330	1.5 - 2.5	4
Low	0 - 30	<1.5	non reportable?

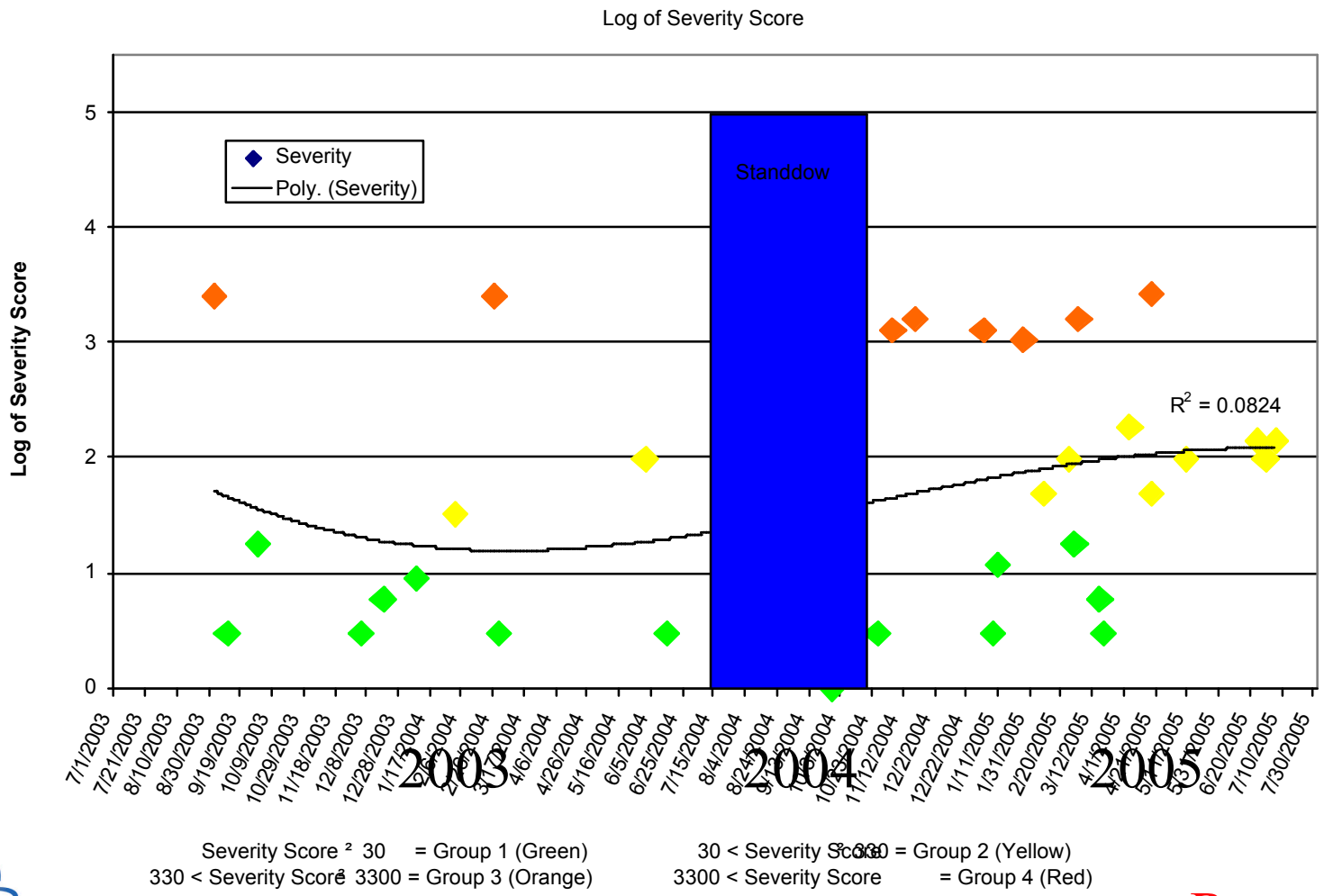
The severity index is used to group the events by severity. We propose that this tool be used as the basis for assigning a severity index to all electrical events in the future. This tool should be used by electrical SMEs to provide for objectively determining the level of hazard present during an electrical event.

Severity Range of Values





Graph of 2 years of LANL Events



Severity Score ² 30 = Group 1 (Green)
330 < Severity Score ² 3300 = Group 3 (Orange)

30 < Severity Score ² 330 = Group 2 (Yellow)
3300 < Severity Score = Group 4 (Red)

Report Chapter 3

Tool Performance

- The tools lead to improved application of the ORPS categorization process in electrical events
- The tool promoted an SME to be at all electrical critiques
- Severity Ranking Tool helps to consistently ask the right questions during a critique
- More accurate failure points determined and bin data
- Uses consensus Electrical Hazard Classification
- Uses national codes and standards for quantification
- Severity # helps to determine what events were severe and where resources should focus, may also indicate precursor to a potential fatality

Event Successes

- Four out of 34 events were under categorized:
  - 480 V arc flash +1
  - 480 V near miss +1
  - complex work with capacitors +1
  - 4000 V shock to student +1
- One event out of 34 was significantly over categorized - 2
  - backhoe severs 120 V line
- 18 events out of 34 were somewhat over emphasized - 1
  - some were not even electrical events
  - most were penetration/excavation events with controls in place
  - some were LOTO procedural errors

Path Forward

- Tools are complete and are going to be piloted at select sites (LANL, SRS, INL, NTS, Hanford, and possibly Brookhaven and PNNL)
- Pilot to be completed by July, 2006
- EFCOG to Recommend to DOE whether tool is ready for complex-wide deployment
- DOE to make determination on complex-wide deployment by September, 2006

Other Applications

- Potential ORPS Screening Tool
  - Screening of electrical events
  - Categorizing events relative to hazard severity